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Mitigation of climate change in terms of the use of renewable energy sources in Bosnia and Herzegovina and mitigation scenarios defined

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Abstract. Many projects that were done in Bosnia and Herzegovina are evident and they aimed at defining mitigation scenarios with measures that will lead to CO₂ reduction by 2025, and by 2040 already defined. Those are as follows: Scenario I (business as usual) In this scenario, it is defined that GHG emissions are growing in proportion to the increase in production / energy consumption (with the implementation of energy efficiency measures). This is the most destructive environmental scenario, where there is no inclusion of renewable energy sources (biogas, geothermal energy, solar energy) Next is Scenario II (reference scenario) This scenario implies the implementation of projects from entity strategies for the development of the electricity sector, with the increase of energy efficiency. And next Scenario III (advanced scenario). This scenario implies the reduction of energy consumption, with the emphasis on the following: increasing the efficiency of (power) plants, next intensive exploitation of the potential of renewable energy sources, and intensive using renewable energy sources; all RES have been taken into account, especially the use of solar energy.

1. Renewable energy sources (RES) in Bosnia and Herzegovina

In paper is showed development of scenarios, where is included overview of existing legislations, activities and data. Overview of basic events and situation in the sector, including legislation, projects, etc, which has direct links or can be associated with "emission reduction".

In paper is showed active legislation, adoption of laws and by-laws in the framework of the mentioned Law Bosnia and Herzegovina:

- Energy Sector Study for Bosnia and Herzegovina, March 2008 Republic of Srpska Energy Development Plan Republic of Srpska (2012.) until 2030,
- Law on Spatial Planning and Construction (Official Gazette of Republic of Srpska, No. 40/13);
- Law on EE (Official Gazette of Republic of Srpska, No. 59/13),
- The Law on RES and Efficient Cogeneration (Official Gazette of Republic of Srpska, No. 39/13) Federation of Bosnia and Herzegovina,
- Law on Spatial Planning and Land Use at the Federation Bosnia and Herzegovina level (Official Gazette Federation Bosnia and Herzegovina, No. 2 / 06,72 / 07,32 / 08,4 / 10,13 / 10,45 / 10),
- Energy efficiency Act (draft, May 2012),
- Law on the use of renewable energy sources (RES) and efficient cogeneration (Official Gazette of Federation Bosnia and Herzegovina No. 70/13).

Projects that involve the use RES for Heat Production: energy from the potential of biogas, solar energy, geothermal energy. Projects that were in the jurisdiction of the city and the mayor's



competence: SEAPs, DELTER projects, USAID PROJECTS 3E, Projects of the Department of Environmental Protection Fund.

1.1. Scenarios related to the use of biogas (BG) in Bosnia and Herzegovina

The S1 scenario is a scenario without taking migration measures, which means that no increase in the use of energy from modern forms of biomass such as biogas (BG) is expected, as energy prices from these sources are still non-competitive in relation to technologies using conventional energy sources. This scenario does not imply the introduction of any changes in the existing trends in the rate of increase in the number of animals and the input of nitrogen fertilizers on arable land. A significant feature of this scenario is the relatively low level of interest and activities of state and entity institutions in this energy subsector.

The S2 scenario, given the very small existing biogas share, is based on activities that focus on implementing the system for its collection and combustion in farms in Bosnia and Herzegovina. The most important features of this scenario are: gradual introduction of new technologies (orientation to the eyes, increased use of RES and biogas), planning of production and energy consumption on farms to meet the needs for space heating, drying of hay, grain, vegetables etc., production of biogas in simple plants and the use of biogas to cover a significant proportion of household energy needs even in a small number of livestock (use of mini-plants).

The S3 scenario is based on a high level of activity to mitigate climate change that is being implemented at different levels of government - from state to entity. More intensive use of biogas for the production of heat and electricity is expected, which will prove to be very profitable thanks to the improvement of the equipment used for this purpose. Biogas from agriculture (livestock breeding) is a significant source of energy in the scenario with measures S2 and S3. These are the cogenerations that are supposed to be efficient locating (electricity generation and heat usage). All electricity generation is transferred to the network, so that its share cannot be divided into categories as a whole. The heat from agricultural plants is given to district heating of rural areas. The total installed capacity of the cogeneration plant for biogas from agriculture (cattle breeding) in the Republic of Srpska is defining two times larger forces for five years. By analogy, the plans have been defined for the Federation of Bosnia and Herzegovina, ie in the following Table 1, the total values at the level of the entire Bosnia and Herzegovina are presented.

Bosnia and Herzegovina, ie in the following Table 1, the total values at the level of the entire Bosnia and Herzegovina are presented.

Table 1. Scenario S3. Total installed power in agriculture of cogeneration plants on biogas (BG) in Bosnia and Herzegovina, and evaluation of events by 2050, [1-3]

Bosnia and Herzegovina	BIOGAS PLANTS	2015	2020	2025	2030	2035	2040	2045	2050
Intalled power	[MW]	2,5	5	7,5	10	12,5	17,5	20,5	23
	GWh/year	5,7	11,54	17,31	23,00	28,8	34,57	41,5	47,5
Production	GgCO ₂ /year	6,98	13,97	20,95	27,84	34,86	41,85	48,87	55,85
Of	PJ/year.	0,02	0,04	0,06	0,08	1,0	1,02	1,05	1,07
electricity	GgCO ₂ /year	0,024	0,05	0,07	0,096	1,21	1,23	1,25	1,27
	GWh/year	11,17	22,34	33,51	44,68	55,85	67,02	77,19	89,36
Production	GgCO ₂ /year	13,52	27,04	40,56	54,09	67,61	81,13	94,64	108,1

heat	PJ/year	0,04	0,08	0,12	0,16	0,2	0,2	0,24	0,28
energy	GgCO ₂ /year	0,048	0,096	0,145	0,113	0,242	0,242	0,288	0,336

In line with scenario 3, we can see Table 1 with installed power in agriculture of cogeneration plants on biogas in Bosnia and Herzegovina, and evaluation events by 2050.

In next figure, we can see total installed capacity in agriculture of cogeneration plant on biogas in Bosnia and Herzegovina and total emissions of GgCO₂ / year, and assessment of events until 2050.

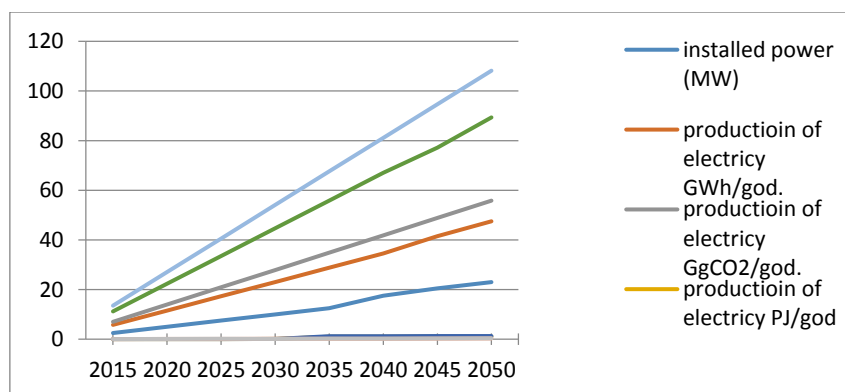


Figure 1. Total installed capacity in agriculture of cogeneration plant on biogas in Bosnia and Herzegovina and total emissions of GgCO₂ / year, and assessment of events until 2050

1.2. Measures to encourage increased use of biogas plants in Bosnia and Herzegovina

Investing in agricultural production is a prerequisite for encouraging the use of biogas. It is generally expected that through the policy of rural development, the application of such measures will result in energy savings in heating wood, electricity, heat energy supplied by district heating and, in particular, fossil fuel energy. On the other hand, the use of biomass (and biogas) in cogeneration production of heat and electricity is increased. If biomass (including biogas) is predicted as a fuel in the industrial sector, improvements through energy measures are manifested through: reducing the intensity of electricity consumption and useful heat, increasing the efficiency of heat generation technologies, increasing cogeneration in the production of heat and electricity.

Energy savings as a result of the application of measures in industry are shown in Table 2. Since the circumstances in the incentives are negligible, and consequently the production of electricity and heat from biogas, a sharper shift and significant energy savings in industry are expected from the year 2020. Whatever the developed scenarios. For households, for now, there are individual uses on several farms. However, these are too small installations, low power and impact on savings, or almost insignificant when it comes to describing the degree of savings.

According to the scenario with measures - S3, the final energy consumption in the industry would be 9% lower than in S2 by 2025. in the same period, electricity consumption would decrease by about 7%. Energy savings in industry [PJ] using biomass (with biogas) should be estimated to be at least twice as high.

Table 2. Energy savings [PJ] in the industry using biomass (with biogas) for cogeneration for the defined values of the emission reduction of GgCO₂

Savings	2010	2015	2020	2025	2030	2035	2040	2045	2050
Energy savings	0.049	0.608	1.114	1.216	1.26	1.31	1.364	1.413	1.46

[PJ]

Energy savings in industry [GgCO ₂]	176.4	2188.8	4010.4	4377.6	4536	4734	4910.4	5086.8	5263
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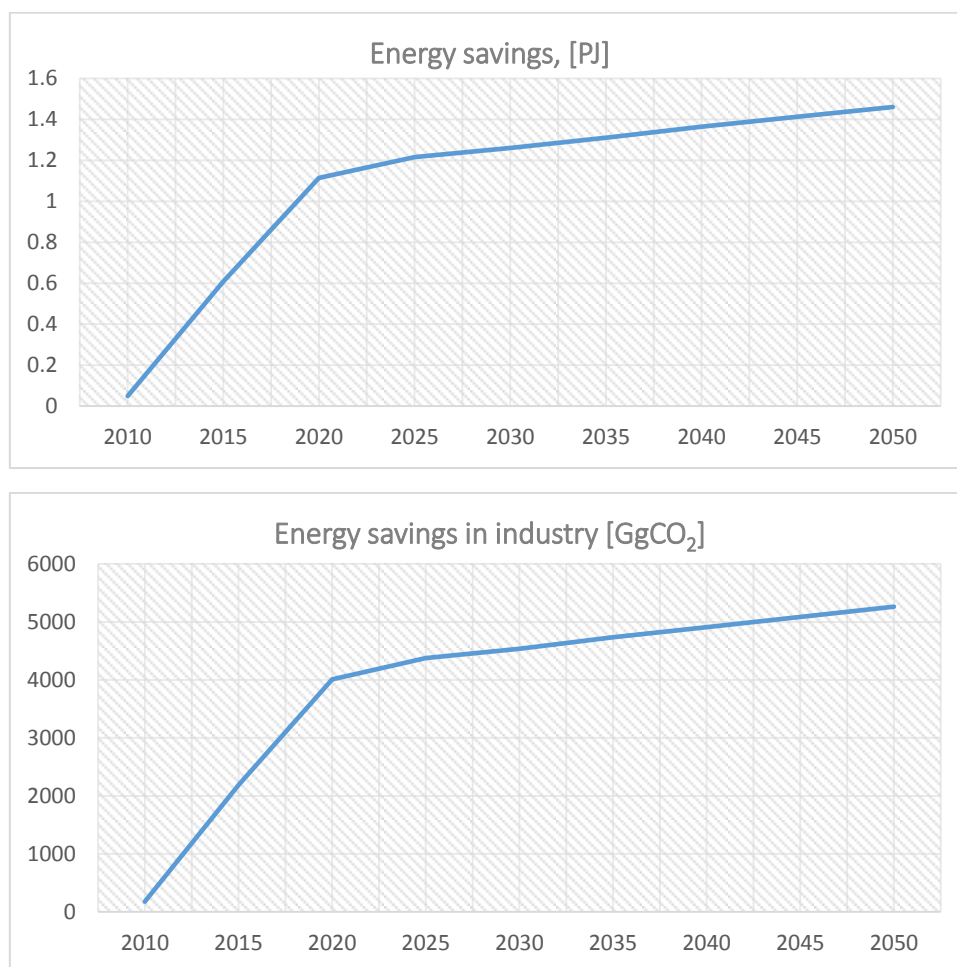


Figure 2. Energy savings according to scenario S3 [PJ] in the industry using biomass (with biogas - BG) for cogeneration by 2050, and saving emissions [GgCO₂] by using biogas

2. Sun energy (SE)

Next RES which was conserved was sun energy. It is showed current situation and changes up to 2050. The results of the research on the possibility of using solar energy for the production of heat – using solar collectors for 15 cities in Bosnia and Herzegovina, as well as for the production of electricity, shows justification based on already initiated initiatives, but unfortunately poor statistics and archiving in these cities. From all the collected data and conducted analyzes, it can be concluded that there is a great potential for the application of solar energy in the territory of Bosnia and Herzegovina, which amounts to 70,5 [mil.Gwh] of the total energy of total solar radiation per year. The technical potential is 685 [PJ], which is about three times more than the total primary energy needs in the energy balance of Bosnia and Herzegovina.

According to the results of the calculation of the possible degree of covering the heat demand for the preparation of hot water for the average household, about 74% of the thermal needs for the preparation of hot water in the Republic of Srpska and 78% in the Federation Bosnia and Herzegovina can be covered from solar collectors. The degree of coverage of heating needs depends on the thermal insulation of the building, but on average it is about 30%. Estimates are that solar energy could settle about 5% of energy needs in B&H. In summer, 80% of hot water needs could be provided, and in the winter between 35 and 50%. Estimates are that in Bosnia and Herzegovina there were about 7,000 square meters of installed collectors, with an annual increase of around 28%. It is estimated that the construction and use of solar collectors, in incentive and co-financing households, as well as public facilities will be proportionally increased.

If we talk about public facilities, these are, above all, hospitals, retirement homes, and sports facilities if they are used throughout the year. In private facilities, these are family houses that have at least five members of the household, whether existing or new buildings. In multi-story buildings, the application of this technology is cost-effective only in the case of a centralized system for the preparation of consumable hot water. If there is an individual preparation, subsequent work and installation in each apartment will greatly increase this technology, which leads to its inefficiency.

High interest and increased use of solar collectors in all sectors can be noticed. A lot of projects have been launched, there is especially significant public sector activity (eg school roofs, hospitals, etc.), where electricity is produced and part of the energy needed to cover heat needs. Activity and growth in all three sectors should be emphasized.

2.1. Scenarios related to the use of solar energy (SE) in Bosnia and Herzegovina

S1 scenario does not imply the introduction of significant changes in relation to the current trend of solar energy use, that is, the state according to which solar energy will not be used in a higher degree. S2 script and S3 script. In Bosnia and Herzegovina, an initiative for the use and production of equipment has begun, and consequently a more intensive and active analysis of the cost-effectiveness, sustainability and energy efficiency of solar systems. Prices are based on those from imports, from Western countries and the Far East. If we look at the standard system of 4 m², the price of a complete system with installation is estimated at around 3,500 to 4,000 euros, it is expected that the installed surface of solar collectors until 2040. it grows up to 100,000 m², which would be about 25 m² per 1,000 inhabitants. If co-financing measures are applied in view of the existing potentials, we can expect coverage of around 200,000 m² by 2025, i.e. about 42,000 households, which is about 11% of the total number of households, and proportionally to 2040 growth. The application of this technology, considering its cost-effectiveness, is most desirable in buildings that are used throughout the year in all aspects of their stay, ie, using consumable hot water. Developed scenarios S2 and S3, by 2040, with a five-year display threshold in a diagram, followed by a commentary on the results obtained.

Table 3. Energy savings in major areas of consumption, using solar energy, for 3 sectors, [PJ] and saving emissions [GgCO₂] for defined savings values) displayed on a diagram, followed by a commentary on the obtained results

No	Saving energy	2010	2015	2020	2025	2030	2035	2040	2045	2050
1	SE – in industry [PJ]	0.00	0.011	0.029	0.047	0.065	0.083	0.101	0.119	0.137
	[Gg CO ₂]	0	39.6	104.4	169.2	234	238.8	363.6	488.4	613.2
2	SE - in households	0.00	0.009	0.056	0.103	0.15	0.197	0.244	0.291	0.338
	[Gg CO ₂]	0	39.4	201.6	370.8	540	709.2	828.4	947.6	1066.8
3	SE - in	0.001	0.002	0.015	0.028	0.041	0.054	0.067	0.080	0.093

services									
[Gg CO ₂]	3.6	7.2	54	100.8	147.6	194.4	241.2	288.0	336.8

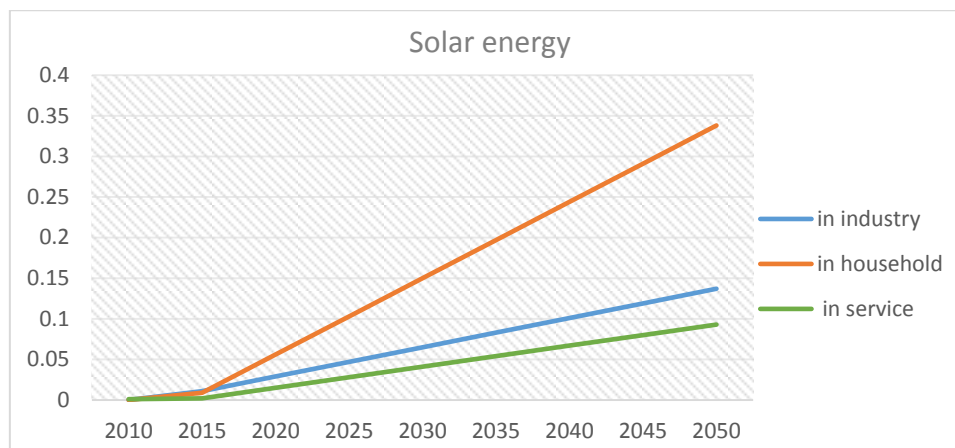


Figure 3a. Diagram showing energy savings, using solar energy (SE) for S3 consumption sectors [PJ]

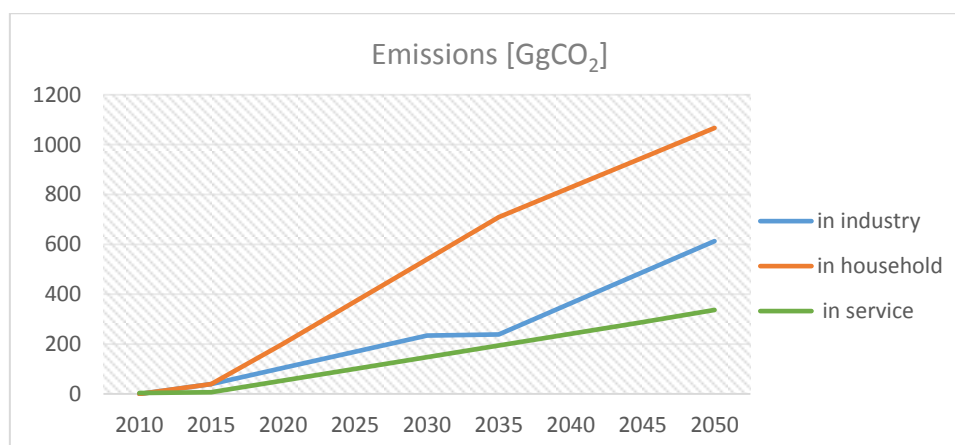


Figure 3b. Diagram showing emission savings, using [GgCO₂]

Compared to the baseline scenario, the use of solar energy for heat needs by 2050 is also increased: in industry by 10%, in households by about 25%, and in the service sector in the amount of 6,7% of useful needs.

2.2. Measures to encourage increased use of solar energy in Bosnia and Herzegovina

The initial step in the measures to encourage the use of the SE, as all other forms of RES, is to give impetus to the launch of SE production. In Bosnia, for now, there are initial - real possibilities i.e. capacity for production. A greater possibility is expected to be encouraged by applying a number of different measures. When it comes to the use of SE solar cells for electricity production in Bosnia and Herzegovina, this has just started to be analyzed and applied, but without significant figures, percentages that could be said in terms of already implemented savings. Solar collectors are analyzed for central heating systems for fuel oil, electricity, LPG (liquefied petroleum gas) - tank and natural gas, where the collector replaces the classic electric boiler for Pvt.

Due to the investment in solar collectors, the total annual costs of the observed system are increased, with the largest increase in the annual cost (in houses with central heating in the cold zone) a combination of boilers for central heating and Pvt on electricity and collectors (5,1%) , followed by

natural gas and collector (5,0%), LPG tank and collector (3,0%) and fuel oil and collector (2,9%). The highest savings were obtained in the combination of boilers for central heating and Ptv on electricity and collectors (5,4%). More intensive cell construction can be expected by the end of 2040, the installed power of photovoltaic systems per capita in Bosnia and Herzegovina, i.e. a total of 60 MW installed system power. Technological development of solar cells is moving in two directions - the development of solar cells with high efficiency of transformation of solar radiation in electricity and development so-called *Low-cost solar cells*. The application of these measures results in energy savings of heating wood, electricity, heat supplied by district heating, and fossil fuels. On the other hand, the use of solar energy is increased (Table 27). According to the scenario with measures - S3, the final energy consumption in industry would be 9% lower than in the base scenario by 2025 - S1. The use of solar energy (SE) in households by 2025 should increase by five times. In B&H, there is a sensible planned project activity, with different types of domestic and foreign financing, in all three sectors.

3. Geothermal energy (GE)

The third RES considered was geothermal energy. The geothermal resource of Bosnia and Herzegovina is of a triple shape: hydrothermal systems, geographical areas and warm dry rocks. These areas cover mainly the central and northern part of Bosnia and Herzegovina. Of the three types of resources mentioned above, the most attention is drawn to hydrothermal systems, because their exploitation is the most developed and cheapest in comparison to the other two forms. By compiling the potentials of Republic of Srpska and Federation Bosnia and Herzegovina, the total thermal power and energy of geothermal phenomena in Bosnia and Herzegovina were calculated. The total possible installed capacity of geothermal sources at 42 locations is 9,25 MWt, if only the possibility of space heating, i.e. 90.2 MWt is considered, if geothermal energy is observed for space heating and recreational and balneological needs. With the use of all mentioned sources with a 0,5-point recovery factor, it is possible to produce 145,75 TJ energy in one year only for space heating, i.e. a total of 1.42175 TJ energy if one looks at the space heating and bathing together. The conducted research shows that a large part of the Republic of Srpska is perspective in terms of the presence of geothermal waters, mostly in the area of Posavina, Semberija, Banja Luka basin and Lijevo polje. The energy potential is estimated at 1260 RJ. The greatest A step forward was made in relation to the planned, in spite of the fact that the concessional policies began to be realized. Concession realizations are happening intensively in the territory of Banja Luka, Sarajevo, Bijeljina and Doboj, as well as plans related to the implementation of deep wells in order to heat the gardens. According to the previous research it was found that about 25% of the territory of Bosnia and Herzegovina is considered a potential geothermal resource.

Description of the scenario. Each scenario in one paragraph (passage) is described descriptively, with the main features that make and characterize it. Scenarios related to the use of geothermal energy in Bosnia and Herzegovina for the use of this energy source is in aquaculture, agro-culture, and heating of settlements.

3.1. Scenarios related to the use of geothermal energy in Bosnia and Herzegovina for the use of this energy source is in aquaculture, agro-culture, and heating of settlements

The scenarios related to the use of geothermal energy are mainly based on the estimated reserves as well as the technological possibilities for its exploitation. The S1 scenario is based on existing trends in the potential use of geothermal energy without any special additional exploration of the potential and without changing the attitude towards this energy source. The highest increase in the consumption of geothermal energy is assumed in the S1 scenario, in the period 2015-2025, amounting to about 2,5%.

The S2 and S3 scenarios are based on the introduction of a support model, where the main activities are focused on the implementation of hydrothermal systems on the whole Bosnia and Herzegovina level. In both scenarios, final energy consumption indicators are given along with the

average annual rates of increase or decrease in five-year periods and the shares of the form of energy in final consumption. There is no geothermal energy as a participant in the structure of electricity generators in S2 and S3, although there are conditions for this, that is, at some locations, concessionaires - concession interest and already realization are happening intensively in the territory of Banja Luka, Bijeljina and Doboj, and realization of plans for realization of deep wells in order to heat the gardens is realized.

The S3 mitigation scenario with the implemented measures is very important considering the envisaged EU accession program for the EU between 2015 and 2020 or the takeover of GHG emissions reduction commitments. According to S2 and S3, a significant representation of the use of geothermal resources by heat pumps in the household sector is assumed. Developed scenarios, by 2050, with a five-year threshold of presentation in the diagram, accompanied by a commentary on the obtained results.

Note: The energy production from Renewable energy source for GgCO₂ emissions is made in relation to electricity consumption, considered to be the only correct aspect, since it is not treated in heating plants, i.e. remote heating.

The electricity eligibility factor for 2014 was taken: 0,744 0,826 (Source: Production - Consumption: for 2011: 0,850 t CO₂ / MWh 0,944 for 2012: 0,730 t CO₂ / MWh 0,811 for 2013: 0,720 t CO₂ / MWh 0,800).

Table 4. Consumption of geothermal energy in Bosnia and Herzegovina according to scenarios S1, S2 and S3, and GgCO₂ emissions for defined scenarios

Geothermal energy. Consumption [PJ] energy	2010	2015	2020	2025	2030	2035	2040	2045	2050
S1 scenarios Emissions [GgCO ₂]	0.0	0.05	0.05	0.09	0.095	0.1	0.15	0.2	0.25
S1 scenarios Emissions [GgCO ₂]	0	180	180	324	342	360	540	720	860
S1 scenarios Emissions [GgCO ₂]	0.0	0.04	0.06	0.06	0.07	0.08	0.09	0.1	0.11
4 S1 scenarios Emissions [GgCO ₂]	0	0.04	216.6	216.6	252.7	288.8	324.9	361	408
S1 scenarios Emissions [GgCO ₂]	0.0	0.04	0.06	0.07	0.07	0.08	0.09	0.1	0.11
S1 scenarios Emissions [GgCO ₂]	0	144.4	216.6	216.6	252.7	288.8	324.9	361	408

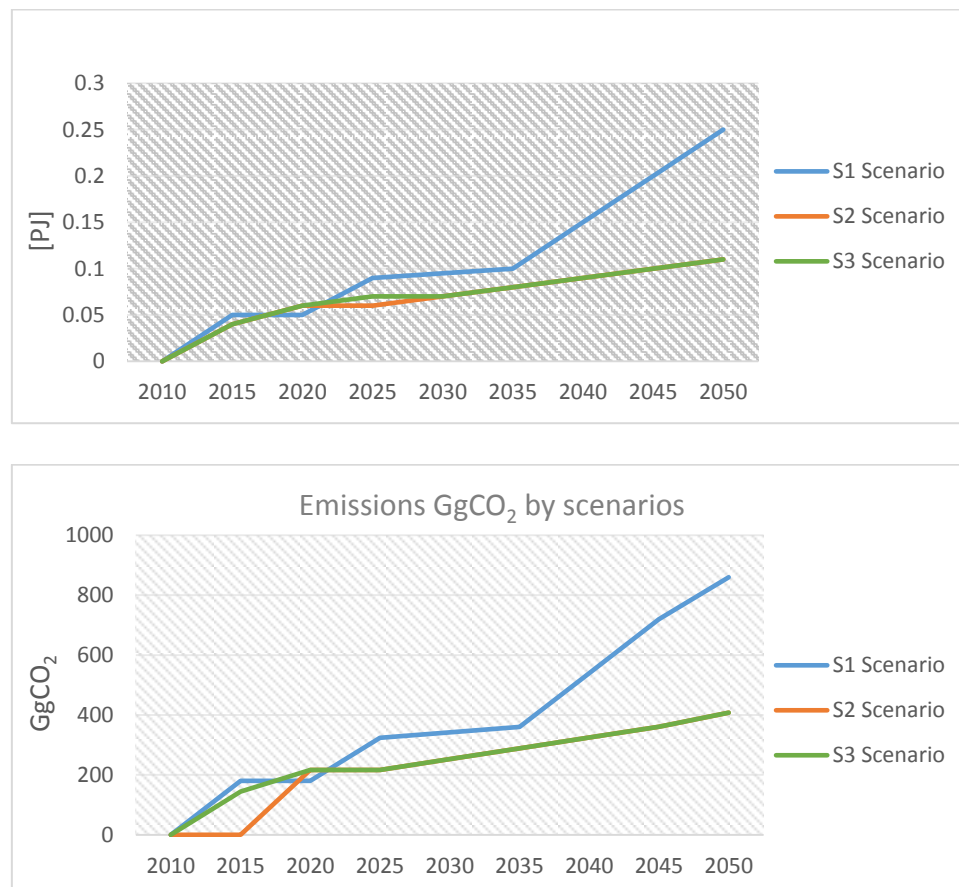


Figure 4. Diagram showing consumption of geothermal energy in Bosnia and Herzegovina (GgCO₂ / year). and emissions GgCO₂

4. Conclusion

Biogas. Based on available livestock data for 2010 and 2011, biogas production potential was estimated from 800,000 to 850,000 m³ / day. So far, only one biogas plant in Bosnia-Herzegovina has been constructed (designed and constructed) in the territory of Srbac municipality. The second biogas plant is in the phase of completion and experimental testing at Donji Žabari near Brčko. The installed electric power of the first plant mentioned is 35 kW and a heat of 70 kW. In households, there are currently single use at several farms. However, these are too small installations, low power and little impact on savings, or almost insignificant when it comes to the degree of savings.

Sun energy. The results of exploring the possibility of using solar energy for heat generation using solar collectors for 15 cities in Bosnia and Herzegovina, as well as for electricity generation, show justifiability on the basis of already initiated initiatives. Estimates are that there are about 7,000 m² of installed collectors in Bosnia and Herzegovina, with an annual increase of around 28%. It is possible to notice the great interest and increase in the use of solar collectors in all sectors. A large number of projects have been launched, and particularly those in the public sector (e.g. solar roofs of schools, hospitals, etc.) where electricity is produced and part of the energy is used to cover the heat needs. The estimate is that proportionally with incentive and co-financing will increase the construction and use of solar collectors both in households and in public facilities.

Geothermal energy. The geothermal resource of Bosnia and Herzegovina is of a three-dimensional form: hydrothermal systems, geoprocessed zones and warm dry rocks. These areas mainly cover the central and northern part of Bosnia and Herzegovina. Of these three forms of resource, the greatest attention is drawn to hydrothermal systems, because their exploitation is the most developed and least

expensive in relation to the other two forms. By aggregating the potential of the Republic of Srpska and the Federation Bosnia and Herzegovina, the total heat power and geothermal energy of Bosnia and Herzegovina were calculated. The total installed capacity of geothermal sources at 42 sites is 9,25 MWt if only the heating capacity is observed, i.e. 90,2 MWt if geothermal energy is observed for space heating and recreational and balneological needs. With the use of all the mentioned sources with the utilization factor of 0,5 it is possible that in one year 145.75 TJ of energy will be generated only for space heating, ie a total of 1.42175 TJ of energy if space heating and bathing are contemplated together. The conducted research shows that a large part of the RS is prospective in terms of the presence of geothermal water, mostly in the area of Posavina, Semberija, Banja Luka valley and Lijevče fields. The energy potential was estimated at 1260 TJ. The greatest potential for using this energy source is in aquaculture, agro culture and heating of settlements. According to the previous research, it is established that about 25% of the territory of Bosnia and Herzegovina is considered as a unavailable. Still with a small share, but with a modest expansion trend, heat pump systems are applied to small and medium objects. A breakthrough has been made since concession policies have begun to be realized. Concessional realization takes place intensively in the areas of Banja Luka, Sarajevo, Bijeljina and Doboј, and plans are being made to realize the deep wells in order to heat the cities.

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